9.13 Dielectric voltage-withstand test (after standard-level unit short-circuit test)

9.13.1 The motor control center unit shall be subjected to a 50 or 60 Hz essentially sinusoidal potential of twice the rated potential plus 1 000 V applied as follows:

a) between line and load terminals of the protective device assembly with the protective device open (that is, with the circuit-breaker in the tripped position with current limiters in their holders, or with the disconnecting means open and the fuses in their holders, as applicable);

b) between line and load terminals of the disconnecting means with the disconnecting means open (that is, between line terminals of the disconnecting means and the line side of the fuse or current limiter, as applicable);

c) between terminals of opposite polarity with the disconnect switch or circuit-breaker contacts closed;

d) between live parts and the overall enclosure with the disconnect switch or circuit-breaker contacts both open and closed.

NOTE Where it is more convenient to do so, the dielectric strength test may be made by applying a dc voltage instead of an ac voltage, provided that the voltage used is 1.4 times the values specified above.

9.13.2 A motor control center unit may be removed from the motor control center section when conducting the dielectric test described in Clause 9.13.1.

9.13.3 The test potential shall be supplied from a transformer as detailed in Clause 9.5.6, following the described method of application.

9.13.4 See Clauses 9.5.2 to 9.5.5 for other test details, as applicable.

9.14 Trip-out test for circuit-breakers (after standard-level unit short-circuit test)

9.14.1 Magnetic trip-out test for circuit-breakers used with Type D and Type E controllers

9.14.1.1 Each pole shall be subjected to a magnetic trip-out test at the setting used during the standard-level unit short-circuit test and shall perform in accordance with the requirements of Clause 8.3.14. The initial test current shall be set at some value below the trip setting and adjusted upward until the breaker trips.

9.14.1.2 The test method may be impulse testing with synchronous closing or with another method that has been found to give accurate indication of the current at the tripping point.

9.14.2 Inverse-time trip-out test for circuit-breakers used with Type C controllers

9.14.2.1 When tested under the conditions specified in Clauses 9.14.2.2 to 9.14.2.8, breakers carrying 200 % of their rated current shall operate within the time limits given in Table 33.

9.14.2.2 Breakers may be mounted in any position unless there are features that can affect their test performance if not mounted in some particular position.

9.14.2.3 The tests may be made at any convenient voltage and with either ac or dc if the breaker is suitable for both. The tests shall be made with ac for a breaker marked for ac only or with dc for a breaker marked for dc only.

9.14.2.4 If breakers are marked specifically for a given frequency, tests shall be conducted at that frequency. If the frequency is not marked, a 48 to 62 Hz supply shall be used.

9.14.2.5 Except as specified in Clause 9.14.2.6, the conductors used in connecting a breaker for the calibration tests shall be of copper, or aluminum if the breaker is marked for use with aluminum conductors only, and not less than 1.2 m (4 ft) in length. The size of the conductor shall be chosen in accordance with Table 18 for 75 °C insulation.

9.14.2.6 For a breaker rated more than 30 A but not more than 125 A, the conductor size shall be based on the temperature rating of the wire as marked on the breaker. Where a dual (60/75 °C) temperature rating is shown, a test shall be conducted for each wire size or for the most adverse one if it can be determined.

9.14.2.7 Each pole of a multipole circuit breaker shall be tested separately.

9.14.2.8 Thermal trip-out tests shall be conducted at room temperature.

9.15 Short-circuit (high-level) test for motor control center units

9.15.1 Testing requirements

9.15.1.1 The tests described in Clause 9.15 are optional tests intended to evaluate combination motor control units rated at short-circuit current levels greater than the values given in Table 31.

9.15.1.2 Units containing only control-circuit components with a short-circuit protective device shall not be required to be tested in accordance with Clause 9.15. These units shall be assigned a short-circuit current rating not greater than the interrupting rating of the short-circuit protective device, but not exceeding 100 kA.

9.15.1.3 Units containing combination motor controllers not previously tested to the applicable high current requirements as referenced in Annex C, item 10, shall be tested as outlined in Clauses 9.15.1.6 to 9.15.5.

9.15.1.4 If the interrupting rating of a circuit-breaker in a combination starter is lower than the proposed marked short-circuit current rating of the combination starter in accordance with Clause 6.3.10, the combination shall be evaluated and subjected to the appropriate requirements as described in Annex C, item 7.

9.15.1.5 Units containing combination motor controllers that have been previously tested to the applicable high current requirements referenced in Annex C, item 10, shall be tested as outlined in Clauses 9.15.1.6 to 9.15.5.5 except as modified by Clause 9.15.6.

9.15.1.6 The test circuit shall have the characteristics specified in Table 39.

9.15.1.7 If multiple short-circuit tests are required in accordance with Clause 9.15.5.3, after each short-circuit operation, the contacts of the motor control devices or the entire motor control device may be replaced and new current elements may be installed in the overload relay. The same sample may be used provided that no additional impedance is introduced. If an overload relay employs non-interchangeable current elements, the entire overload relay may be replaced.

9.15.1.8 Alternating-current tests shall verify ac ratings only. Direct-current tests shall verify dc ratings only. See Annex A, Clause A2, for ac circuit calibration. See Annex A, Clause A3, for dc circuit calibration.

9.15.1.9 Incoming line circuit connections and calibrations shall be made in accordance with Clause 9.10.7 and 9.10.8.

9.15.2 Sample selection and preparation

9.15.2.1 A unit having the smallest dimensions and the least provision for pressure relief shall be selected.

9.15.2.2 During the test, the section or sections shall be mounted as in service, with the sample unit mounted in the section. The unit door shall be held closed only by the intended latch mechanism and securement means. No other units need to be installed, but all doors and covers shall be in place, and unused openings shall be closed.

9.15.2.3 The load-terminal connections for motor starter units shall be made with leads of insulated copper wire, each of which has an ampacity, as specified in Table 18, of at least 125 % of the maximum full-load motor-current rating of the current element. Unless the unit is marked for 75 °C wire only, the wire shall be acceptable for a temperature of 60 °C for a full-load current rating of 100 A or less and shall be acceptable for 75 °C for a full-load current rating greater than 100 A. The load-terminal leads shall be connected together. Each load lead shall not be longer than 1.2 m (4 ft).

9.15.2.4 The metal enclosure shall be connected to the phase of the source of supply that is connected to the pole judged as having the least risk of arcing to ground. The connection shall be made to the load side of the limiting impedance by a 5.3 mm^2 (10 AWG) solid copper wire that is 1.22 to 1.83 m (4 to 6 ft) long. Continuity shall be verified between the enclosure and the pole least at risk of arcing to ground.

9.15.2.5 For equipment marked 600Y/347 or 480Y/277 V, or a wye voltage rating greater than 600Y/347V, the enclosure shall be connected to the center of the wye.

9.15.3 Overload relay

9.15.3.1 Samples for the test shall be selected among motor control devices employing the largest and smallest current element that can be used with the protective device specified for the motor control device.

9.15.3.2 The maximum number of current elements that can be accommodated by the device shall be in place during each test. Three-phase tests shall be considered to cover single-phase tests for a device of the same design.

9.15.3.3 A solid state overload relay with line terminals, load terminals or both shall be selected and tested according to 9.15.3.1 and 9.15.3.2. A pass through overload relay having no main terminals, where power conductors pass through current transformers only, may be evaluated by a single representative sample specified for the motor controller.

9.15.4 Protective devices

9.15.4.1 For combination motor control units with circuit-breakers, the protective devices used for the test shall be the largest used in a manufacturer's selection process.

9.15.4.2 For a motor control device or overload relay intended to be used with fuses, the protective devices used for the test shall be sized in accordance with Table 28 and shall be selected as follows:

a) Fuses specified for branch-circuit protection for motor control devices rated over 10 000 A shall be limited to high-interrupting capacity, current-limiting types (e.g., Class CC, G, J, L, R, and T), with the following exception: a motor control device rated 37 kW (50 hp) or less and tested at 10 000 A may specify Class H or K fuses for motor-branch-circuit protection.

b) A motor control device that is required to be used with RK1 or RK5 fuses shall be tested with fuses having I^2t and I_p characteristics for Class RK5 fuses. All references to Class R fuses are intended to mean fuses with energy let-through, I^2t, characteristics of Class RK5 fuses.

c) A Class CC, G, J, L, R, or T fuse shall be selected such that, when tested on a single-phase circuit, the peak let-through current and clearing I^2t are not less than the maximum value established for the fuse that is intended to be used with the controller being tested (see Annex C, items 18 to 26). For a fuse with I_p and I^2t limits established for several different short-circuit current levels, the test fuse shall be selected so as to have at least the maximum values of the current corresponding to the marked short-circuit current rating of the motor control device. The following conditions shall apply:

1) a test limiter may be used in place of the fuses;

2) combination motor controller self-protecting control devices shall be provided with integral short-circuit and ground-fault protection.

9.15.4.3 If a test shall be performed on series-connected circuit-breakers, the circuit-breakers shall be selected consistent with their coordination in accordance with the standards for moulded-case circuit-breakers and circuit-breaker enclosures (see of Annex C, item 7).

9.15.5 Procedure for combination controllers not previously tested at high current

9.15.5.1 A combination controller shall be tested according to the requirements in Clauses 9.15.5.2 to 9.15.5.5. The terminals of the test circuit described in Clause 9.10.7 shall be connected together by a copper bar, and the test circuit shall be calibrated as described in Clause 9.10.7 at the maximum available short-circuit current for which the motor control device is rated. The short-circuit current level and rating of the unit shall be one of the values shown in Table 2.

9.15.5.2 The test circuit shall have the characteristics specified in Table 39 for ac circuits and Table 42 for dc circuits.

9.15.5.3 For the short-circuit-closing test (“CO” shot), each switching device of the motor control device shall be closed on the test circuit. There shall be separate tests for each switching device, as specified in Table 40: one in which the disconnecting means, when provided, is closed on the circuit, and a second in which the contactor is closed on the circuit. Complete physical closure of the switching contacts shall not be required to be established. When complete physical closure of the switching contact is established, the closing test on the disconnecting means shall be able to cover the withstand test (“O” shot) on the motor control device, and the closing test on the motor control device shall be able to cover the withstand test on the disconnecting means. To determine whether complete physical closure of the contacts has occurred, the oscillogram of the short-circuit current and voltage traces between circuit initiation and current interruption by the protective device shall be reviewed. A smooth sinusoidal waveform in this area of the trace shall be an indication of complete physical closure.

9.15.5.4 The equipment shall be subjected to the number and type of operations specified in Table 40 and shall comply with Clause 8.3.15. Tests shall be conducted with random closing of the test circuit.

9.15.5.5 When closing the circuit on the equipment ("O" shot), the disconnecting means and the motor control device shall be in the fully closed position.

9.15.6 Procedure for combination motor controllers previously tested at high current

The procedure shall be the same as that outlined in Clause 9.15.5 except the combination motor control unit shall be subjected to a single "O" test with each switching device in the closed position prior to energizing the test circuit.

9.16 Dielectric voltage-withstand test (after high-level short-circuit test – motor control center units)

9.16.1 The combination motor controller, main, or feeder unit tested in accordance with Clause 9.15 shall be subjected to the test voltage for 1 min at a 50 or 60 Hz essentially sinusoidal potential, as follows:

a) the unit may be located outside the motor control center;

b) a motor controller may be disconnected during the test;

c) the test potential shall be twice the voltage at which the short-circuit test was conducted, but not less than 900 V;

d) the test voltage shall be applied between a live part and the unit frame with the disconnect switch or circuit-breaker contacts both open and closed;

e) the test voltage shall be applied between the line and load side of the disconnect switch or circuit-breaker contacts with the contacts open.

NOTE Where it is more convenient to do so, the dielectric strength test may be made by applying a dc voltage instead of an ac voltage, provided that the voltage used is 1.4 times the values specified above.

9.16.2 The test potential shall be supplied from a transformer as detailed in Clause 9.5.6, following the described method of application.

9.16.3 See Clauses 9.5.2 to 9.5.5 for other test details, as applicable.

9.17 Trip-out test for circuit-breakers (after high-level unit short-circuit test)

9.17.1 Magnetic trip-out test for circuit-breakers used with Type D and Type E controllers

9.17.1.1 Each pole shall be subjected to a magnetic trip-out test at the setting used during the high-level unit short-circuit test and shall perform in accordance with the requirements of Clause 8.3.17. The initial test current shall be set at some value below the trip setting and adjusted upward until the breaker trips.

9.17.1.2 The test method may be impulse testing with synchronous closing or with another method that has been found to give accurate indication of the current at the tripping point.

9.17.2 Inverse-time trip-out test for circuit-breakers used with Type C controllers

9.17.2.1 When tested under the conditions specified in Clauses 9.17.2.2 to 9.17.2.8, breakers carrying 250 % of their rated current shall operate within the time limits given in Table 33. If the pole under test does not trip within the time indicated in Table 33, the current shall be immediately increased to 400 % of rated current under which condition the pole under test shall trip within 2 additional minutes. This additional 400 % test shall be made on only one pole of a multipole circuit breaker.

9.17.2.2 Breakers may be mounted in any position unless there are features that can affect their test performance if not mounted in some particular position.

9.17.2.3 The tests may be made at any convenient voltage, and with either ac or dc if the breaker is suitable for both. The tests shall be made with ac for a breaker marked for ac only or with dc for a breaker marked for dc only.

9.17.2.4 If breakers are marked specifically for a given frequency, tests shall be conducted at that frequency. If the frequency is not marked, a 48 to 62 Hz supply shall be used.

9.17.2.5 Except as specified in Clause 9.17.2.6, the conductors used in connecting a breaker for the calibration tests shall be of copper, or aluminum if the breaker is marked for use with aluminum conductors only, not less than 1.2 m (4 ft) in length. The size of the conductor shall be chosen in accordance with Table 18 for 75 °C insulation.

9.17.2.6 For a breaker rated more than 30 A but not more than 125 A, the conductor size shall be based on the temperature rating of the wire as marked on the breaker. Where a dual (60/75 °C) temperature rating is shown, a test shall be conducted for each wire size or for the most adverse one, if it can be determined.

9.17.2.7 Each pole of a multipole circuit breaker shall be tested separately.

9.17.2.8 Thermal trip-out tests shall be conducted at room temperature.

9.18 Strength of insulating base and support tests

To determine that an insulating base complies with the requirement, the equipment shall be mounted as intended and may be fitted with a short length of rigid conduit. A short length of field-wiring conductor of rated ampacity shall be routed through the conduit, if fitted, and connected to the terminal. The wiring terminal clamping screw shall be tightened to 110 % of the value of torque specified on the equipment. For equipment marked for use with copper and aluminum conductors, the wire connectors shall be torqued to 110 % of the highest torque value marked for either conductor.

9.19 Comparative deflection test

A force shall be applied at any point on the surface of the enclosure or barrier except for a point on the door or cover, using a flat face of a steel bar 12.7 mm x 12.7 mm (0.5 in x 0.5 in). Force shall be applied to the end, side, and rear walls of each enclosure or barrier. The values of the force and the limit of deflection, both of which shall be measured and recorded, are not specified, but the force on each wall of both the test and reference enclosures shall be sufficient to result in a measurable deflection on the test enclosure.

9.20 Autotransformer starter test

An autotransformer starter or a reactor starter shall have full line voltage applied to the line terminals, and 300 % of the full-load motor-running current at 0.50 maximum power factor shall be drawn from the taps giving 45 to 70 % of normal line voltage. Unless marked to indicate different periods of load and rest, the operating test cycles shall be as follows:

a) for starters rated 200 hp or less, the test shall comprise a duty cycle of 15 s ON and 225 s OFF repeated for a total of 15 cycles in the case of automatically operated starters or for a total of 4 cycles in the case of manually operated starters; and

b) for automatically operated starters rated between 200 and 3 000 hp, the test shall comprise a duty cycle of 30 s ON and 30 s OFF for a total of 3 cycles.

This test may be terminated before the end of the specified period if the autotransformer is prevented from overheating by a reliably operating, nonadjustable thermostat or similar device.

After undergoing the test, the starter shall comply with Clause 8.3.20.

9.21 Insulating barrier dielectric

The barrier material shall be placed between two metal electrodes. The electrodes shall be cylindrical brass or stainless steel rods 6.4 mm (1/4 in) in diameter with edges rounded to a 0.8 mm (1/32 in) radius. The test potential shall be increased to the required test value and shall be maintained for 1 second.

9.22 Factory tests

See Annex F.

10 Application

See Annex H.

TABLES

Table 1
Common voltage ratings

(Clause 5.2)

System		Common voltage ratings
Number of phases	**Number of wires**	**Volts**
1	2	120, 240, or 277 ac
1	3	120/240 or 208Y/120 ac
3 (derived from 3-phase, 4-wire system)	3 or 4	208Y/120, 220Y/127,440Y/254, 480Y/277,400Y/217, 600Y/347, or 690Y/400 ac
3	3	120, 240, 480, 600, 690, or 1 000 ac
3	4-wire delta with the neutral at midpoint of one phase	240/120 ac
NA	2	125 dc
	3	125/250 dc
	2	250 dc
	2	500 dc
	2	600 dc
	2	750 dc
	2	800 dc
	2	850 dc

Table 2
Unit short-circuit current ratings

(Clauses 5.4.1 and 9.15.5.1)

RMS symmetrical or dc amperes	
5 000	42 000
7 500	50 000
10 000	65 000
14 000	85 000
18 000	100 000
22 000	125 000
25 000	150 000
30 000	200 000
35 000	

Table 3
Bus structure
Short-circuit current ratings

(Clauses 5.4.4, 8.3.10, and 9.10.1)

RMS symmetrical or dc amperes	
22 000	85 000
25 000	100 000
42 000	125 000
50 000	150 000
65 000	200 000

Table 4
Branch-circuit short-circuit protection – copper conductors

(Clauses 6.3.53 and 8.2.14.2)

Control-circuit wire size, mm^2 (AWG)	Maximum rating of branch-circuit-protective device, amperes	
	Conductors within center enclosure	Conductors outside center enclosure
0.32 (22)	12	3
0.52 (20)	20	5
0.82 (18)	25	7
1.3 (16)	40	10
2.1 (14)	100	45
3.3 (12)	120	60
5.3 (10)	160	90

Table 5
Allowable ampacities of insulated copper conductors inside motor control centers (based on a room ambient temperature of 40 °C)

(Clause 8.2.13.1)

Conductor size, mm^2 (AWG)	Conductors with 90 °C insulation		Conductors with 105 °C insulation	
	In small or nonventilated enclosure	Large ventilated enclosure	In small or nonventilated enclosure	Large ventilated enclosure
0.20 (24)	1	2	1	2
0.32 (22)	2	3	2	3
0.52 (20)	3	4	3	4
0.82 (18)	4	6	4	6
1.3 (16)	6	9	6	9
2.1 (14)	9	13	10	15
3.3 (12)	12	17	15	22
5.3 (10)	18	27	22	35
8.4 (8)	31	47	35	55
13.3 (6)	45	67	52	80
21.2 (4)	61	91	71	108
26.7 (3)	70	104	80	121
33.6 (2)	80	120	90	140
42.4 (1)	94	141	107	164
53.5 (1/0)	110	164	133	190
67.4 (2/0)	128	191	148	221
85 (3/0)	148	221	171	257
107 (4/0)	173	258	200	300

Table 6
Ampacity correction factors for multiple conductor groupings

(Clause 8.2.13.1)

Number of conductors	Correction factor
1 to 3	1.00
4 to 6	0.80
7 to 24	0.70
25 to 42	0.60
43 and more	0.50

Table 7
Marking locations for motor control centers

(Clause 6.3.2)

Clause reference	Required marking[a]	Location[b]
General		
6.2.2, 6.3.5	Tables, diagrams, and electrical rating information other than as specified in Clause 6.2.1	C
6.3.12	"Suitable for use as service equipment." or "Suitable for use as service equipment when not more than two main disconnecting devices are installed."	A (see Clause 6.3.22)
6.3.14	Instructions for installing the bonding means, in sections or units marked "Suitable for use as service equipment."	
6.3.15	"Service disconnect."	see Clause 6.3.15
6.3.17	1. "Suitable only for use as service equipment when supplying a continuous industrial process." or 2. "Suitable for use as service equipment only if supplying a continuous industrial process."	A
6.3.18	(1) For supplying a fire pump or (2) for an alternate source for legally required standby service or (3) for services where the neutral is not solidly grounded.	A
6.3.19	Similar marking as above except for a motor control center section or unit that has ground-fault protection with only audible or visual signal	A
6.3.23	"Bonded neutral – Must not be disconnected except for testing."	D
6.3.24	Identification of main bonding jumper, grounding electrode conductor terminal, and the neutral disconnect link	D
6.3.37	Identification of Class 1 power supplies and the circuits they supply	C or on or near the circuit terminals (Clause 6.3.37)
6.3.37	Identification of Class 2 power supplies and the circuits they supply	C or on or near the circuit terminals (Clause 6.3.37)
6.3.43	The circuits that are protected by ground-fault protection (main, feeder, or branch)	B or C
6.3.45	"External source connection for control circuit of ground fault sensing and relaying equipment___ V (ac or dc)."	C
6.3.46	"OPEN-OFF" or "CLOSED-ON" position for disconnecting means	A
Wiring terminal markings		
6.3.28, 6.3.29	"Use Copper/Cu Wire Only."	B
6.3.28, 6.3.30	"Use Copper or Aluminum Wire or Cu-Al."	B
6.3.33	The required temperature rating of all field-installed conductors	C
6.3.35	The number and size of wires for which the terminal is acceptable	C
6.3.28, 6.3.31	"Use Copper/Cu Wire Only Except at Terminals ____."	B
6.3.36	The specific tightening torque for the terminals	C
6.3.41	Pressure terminal connectors or component terminal assemblies that are acceptable for use with the equipment	C
6.3.42	Same as above, except with instructions for special terminations	C
6.3.57 b)	The IEC Symbol No. 5019 for the equipment grounding terminal	Adjacent to the equipment grounding terminal
6.3.70	Instructions for disconnecting the bonding conductor that connects the neutral assembly to the enclosure.	Temporary tag or instruction sheet
Cautionary		

Table 7 Continued on Next Page

Table 7 Continued

Clause reference	Required marking[a]	Location[b]
6.3.44	"WARNING" and the following or equivalent: "RISK OF FIRE AND ELECTRICAL SHOCK – DO NOT CONNECT GROUNDING CONDUCTORS TO THESE OR ANY OTHER NEUTRAL TERMINALS; TO DO SO WILL DEFEAT GROUND-FAULT PROTECTION."	On or adjacent to the neutral.
6.3.47	"DANGER" and the following or equivalent "RISK OF ELECTRIC SHOCK. THIS MAIN DOES NOT DISCONNECT CONTROL AND INSTRUMENT CIRCUITS."	A and on the dead front adjacent to the main disconnect
6.3.59	All cautionary markings	A*
6.3.60	"CAUTION", "WARNING", or "DANGER"	On all cautionary markings.
6.3.64	"WARNING: MORE THAN ONE LIVE CIRCUIT. SEE DIAGRAM."	A
6.3.68	"WARNING: TWIST WIRES TOGETHER BEFORE INSERTING IN TERMINAL." and "COPPER WIRES MUST NOT BE MIXED WITH ALUMINUM WIRES IN THE SAME TERMINAL HOLE."	Adjacent to the grounding terminal

[a] These are brief summaries of the marking requirements. For complete details, see the specific clause reference.

[b] The marking locations for the corresponding letters are as follows:

A Marking shall be plainly visible after installation. Markings shall be visible without removing the trim or cover of the enclosure. Markings may be on the front of the enclosure or on the inside of a hinged door.

A * Same as A, except (see Clause 6.3.59) marking shall be located on a part

a) that would require tools for removal; or

b) that cannot be removed without impairing the operation of the product.

B Marking shall be visible

a) when the enclosure cover is removed or the door is open;

b) when other devices are mounted nearby as intended;

c) when devices are installed side by side.

C See Clause 6.3.11.

D Each part shall be identified by a marking (i.e., a label or a direct marking) or tag located on or adjacent to the part.

Table 8
Marking locations for motor control center sections

(Clause 6.3.2)

Clause reference	Required marking[a]	Location[b]
	General	
6.3.4	Manufacturer's name or trademark and type designation, serial number, or equivalent factory identification code	A
6.3.5	Electrical ratings and enclosure type	A
6.3.5	Termination and wiring information	B
6.3.6	Short-circuit current rating of N/A for sections not containing bus	A
6.3.8	Short-circuit-current rating of a section shall be part of a marking containing the manufacturer's name or other required marking.	A
6.3.9	"Short-circuit-current rating ___ A rms symmetrical ___ V maximum. Do not install on circuits with available short-circuit currents higher than the lowest short-circuit current rating of any installed unit" or the equivalent	A

Table 8 Continued on Next Page